

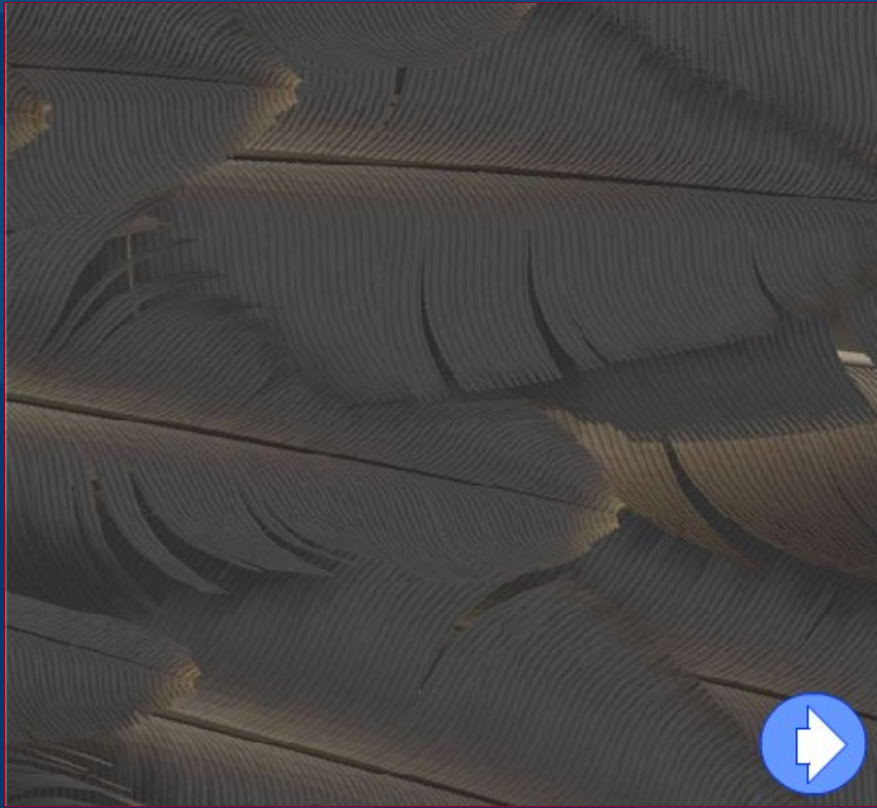
SAN ANTONIO
SIGGRAPH
2002

**Modeling & Rendering of
Realistic Feathers**

**Yanyun Chen, Yingqing Xu, Baining Guo,
& Heung-Yeung Shum**

Microsoft Research Asia

Goals



- **A complete pipeline for modeling & rendering feathers systematically**
- **Realistic details for close-up views**
- **Efficient rendering for a wide range of viewing distances**

Challenges

- **Modeling individual feathers**
 - Mesoststructures of feather blade
 - Different types of feathers
 - Contour feather, flight feather, semi-plume, etc.
 - Everything in between
 - Randomness
- **Feathering a bird**
 - Arranging thousands of feathers on a bird's body

Contributions

- **Modeling & rendering of individual feathers**
 - An L-system for feather geometry
 - A technique for rendering feather mesostructures using bi-directional texture function (BTF)

Contributions

- **Modeling & rendering of individual feathers**
 - An L-system for feather geometry
 - A technique for rendering feather mesostructures using bi-directional texture function (BTF)
- **Feathering a bird**
 - A recursive collision detection algorithm

Related Work

- **Feathers**

[Dai *et al.* 95, Schramm *et al.* 97, Franco & Walter 01, Streit & Heidrich 02]

- **L-system**

[Lindenmayer 68, Prusinkiewicz *et al.* 90, 95, 96, ..., 01, Parish & Müller 01]

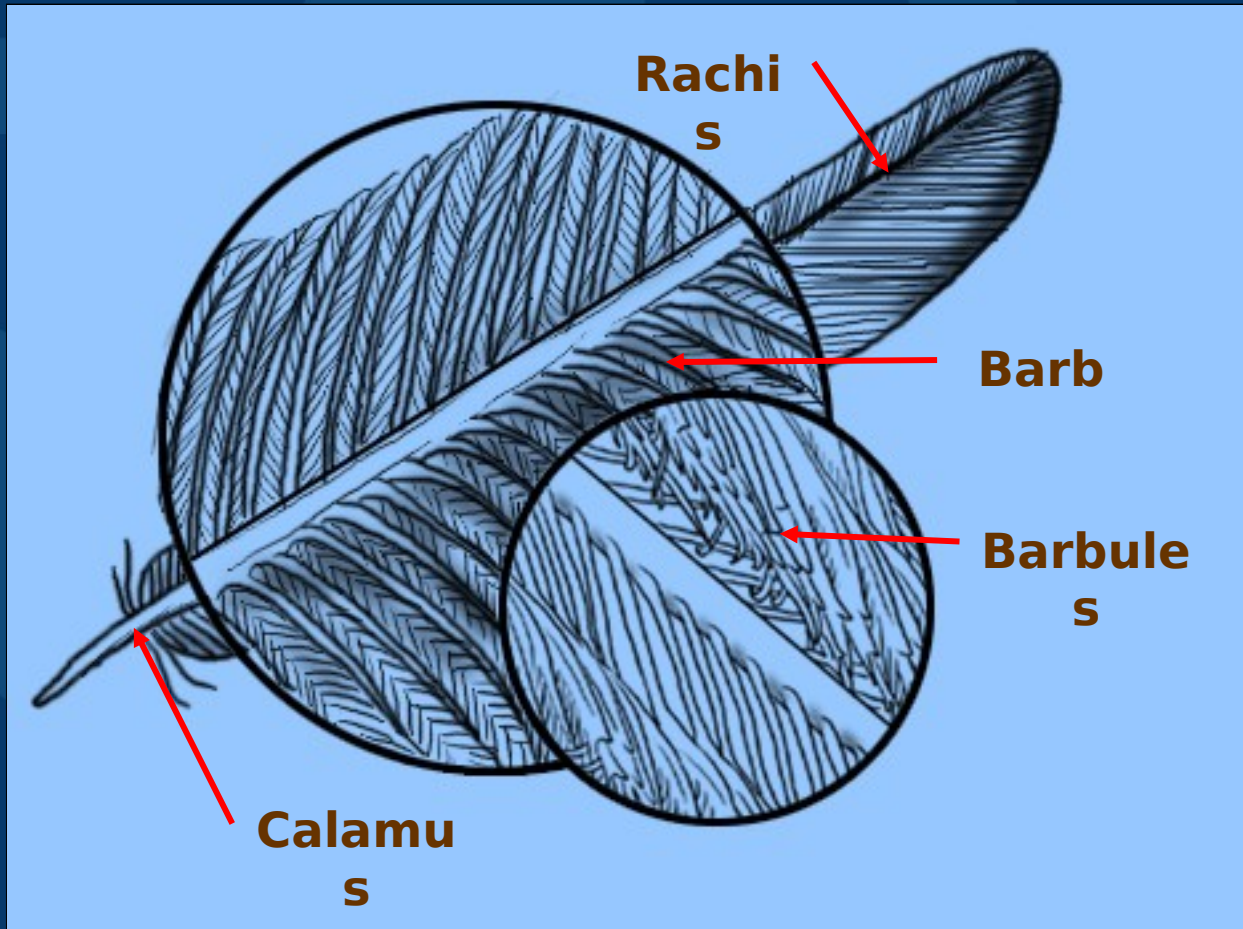
- **BTF**

[Dana *et al.* 97, Liu *et al.* 01, Tong *et al.* 02]

Outline

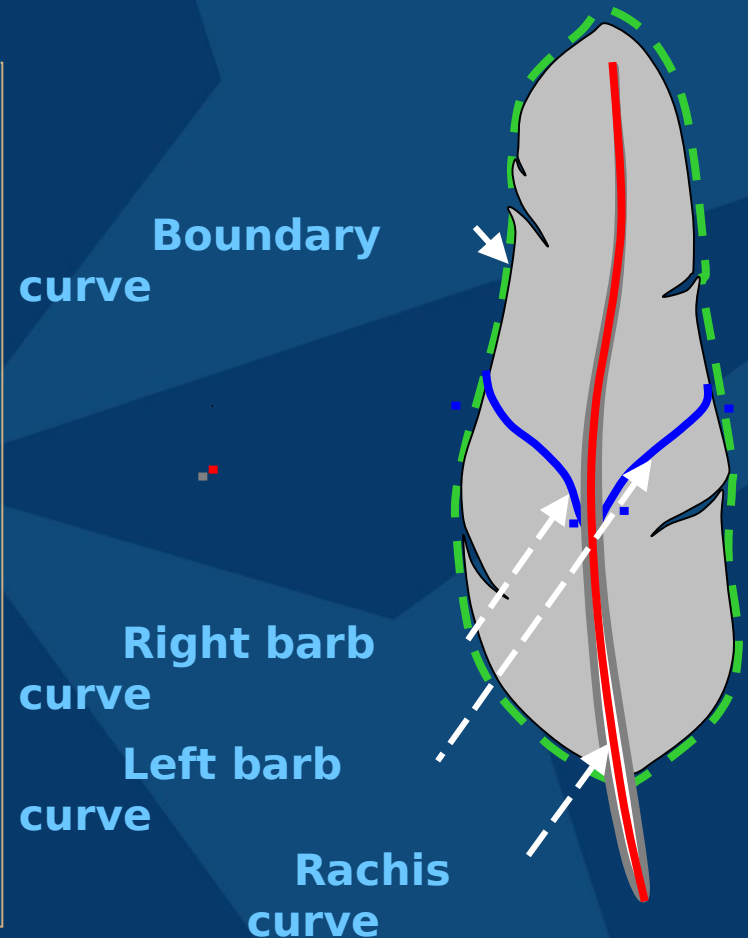
- **Individual feathers**
 - Feather geometry
 - Feather appearance
- **Feathering a bird**
 - Generating feather coat using key feathers
 - Recursive collision detection
- **Results**

Feather Anatomy



Feather Geometry

- **Modeled by L-system**
 - Branching structure
 - Rachis → barb → barbule → barbicle
 - Compact representation
 - Morphing by parametric interpolation
 - Randomness
- **Interactive editing**

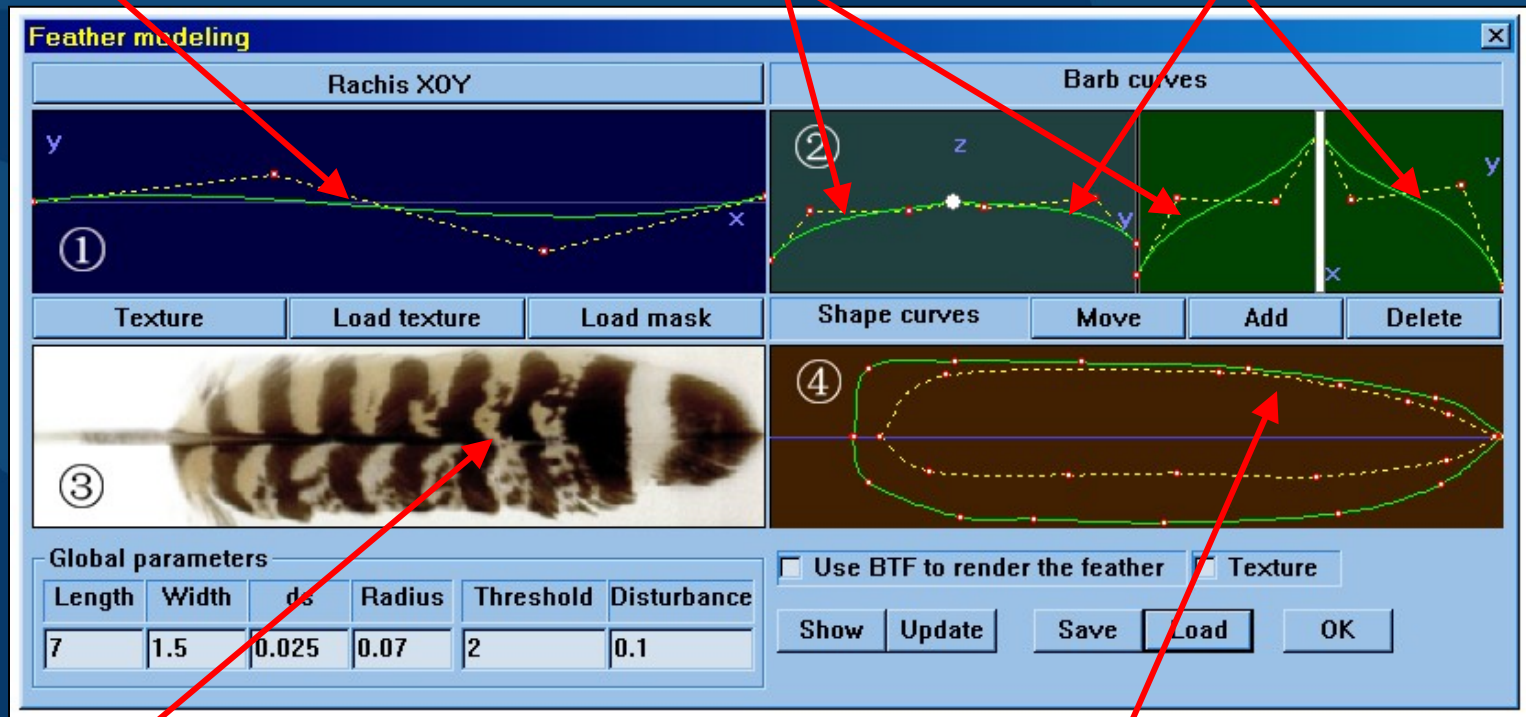


Editing Feather Geometry

Rachis

Right barb

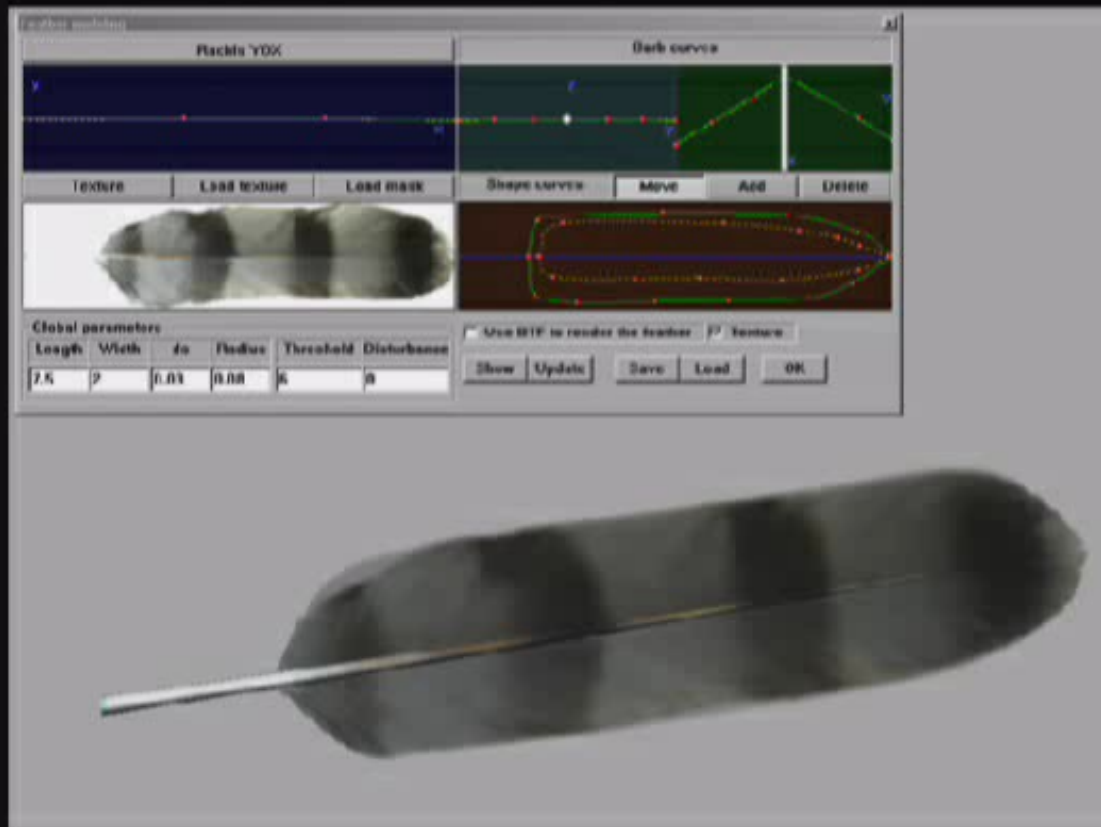
Left barb



Texture

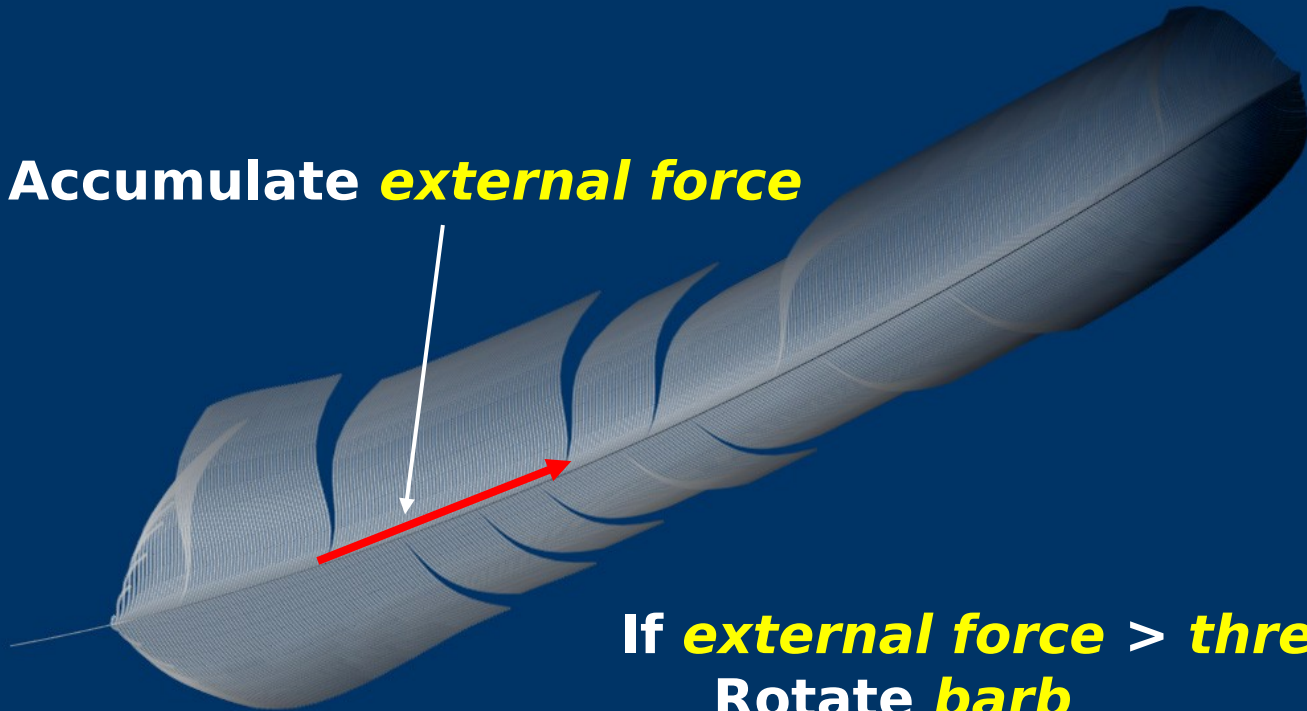
Boundary

Editing Feather Geometry



Adding Randomness

Accumulate **external force**

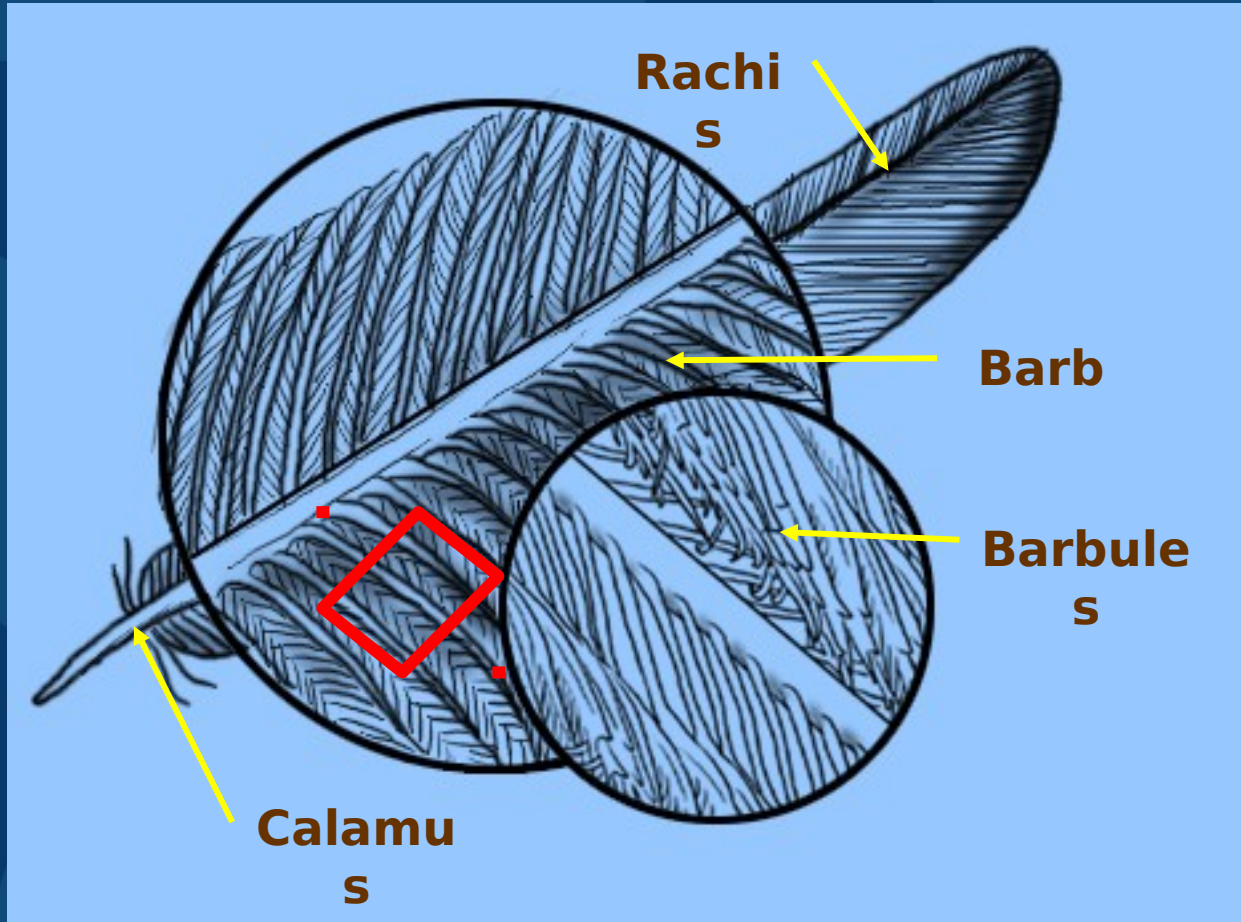


If **external force** $>$ **threshold**
Rotate **barb**
external force = 0

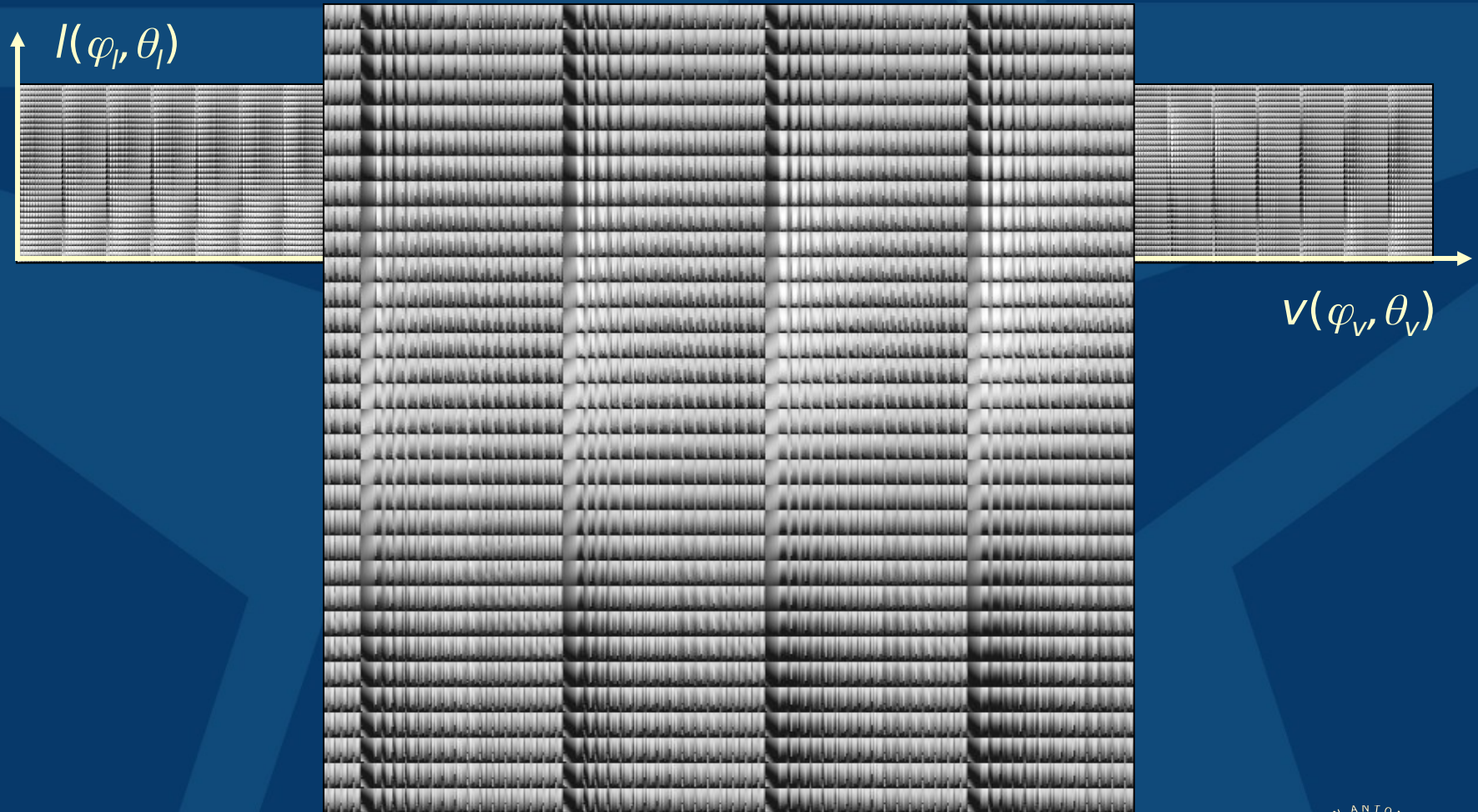
Feather Examples



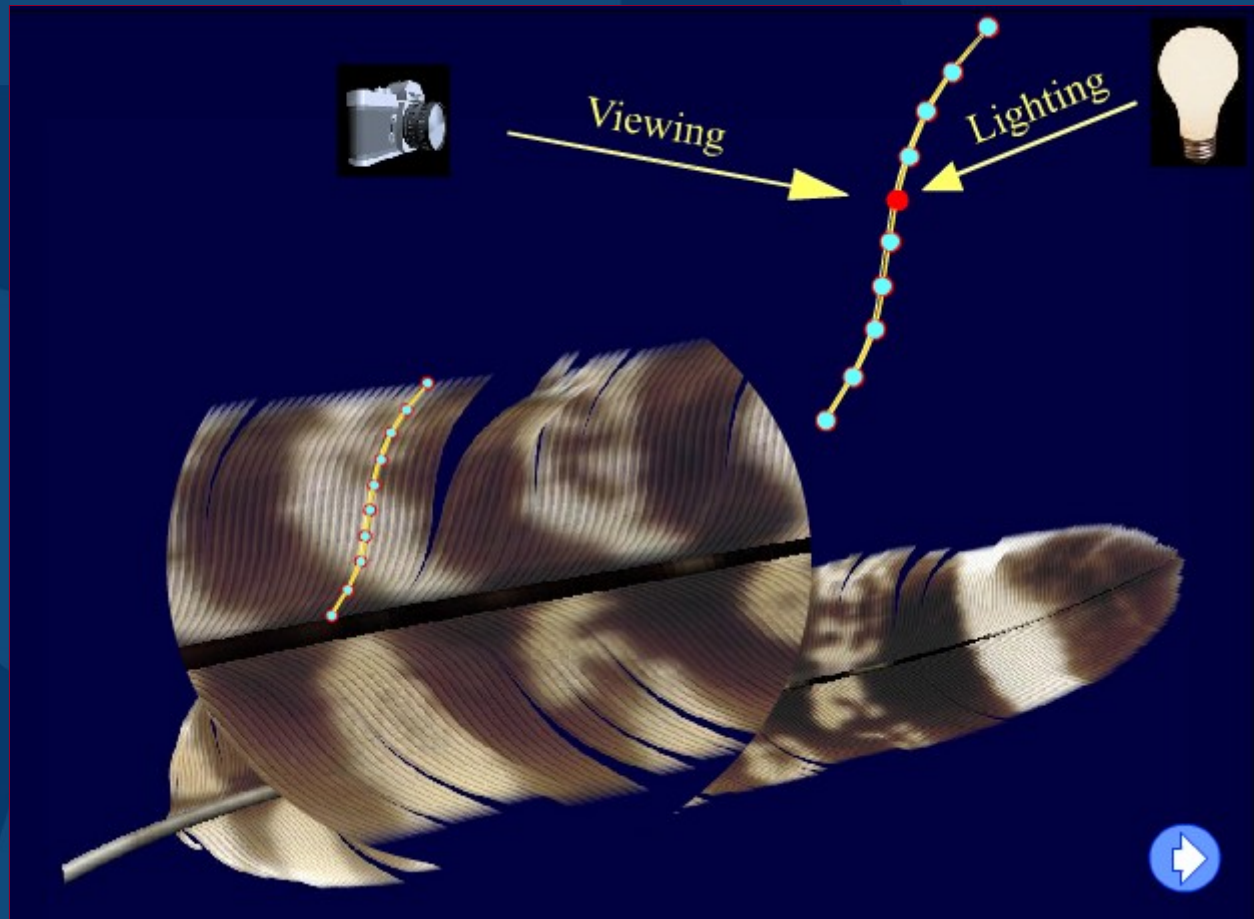
BTF Sampling



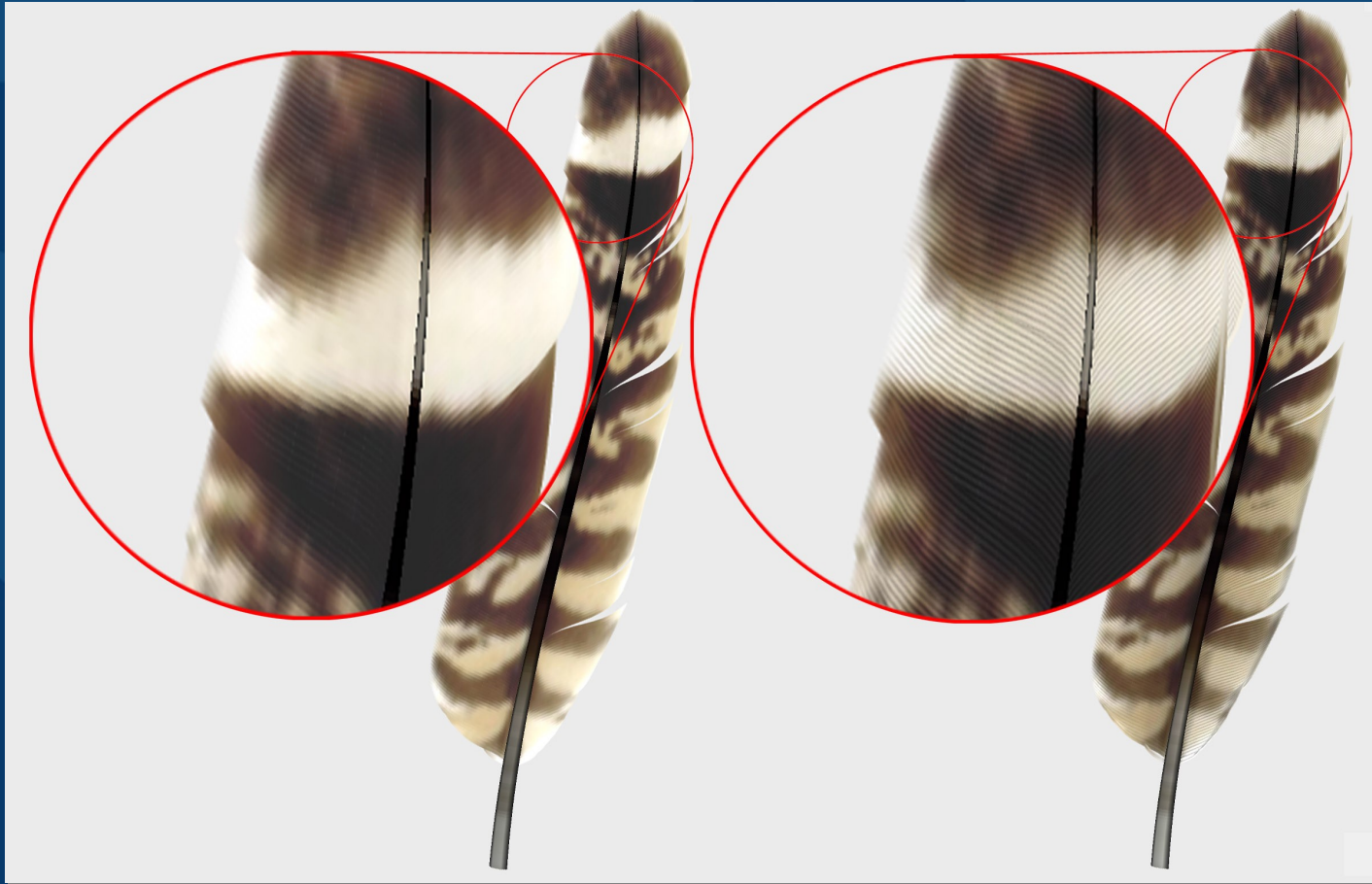
BTF Sampling



BTF Rendering



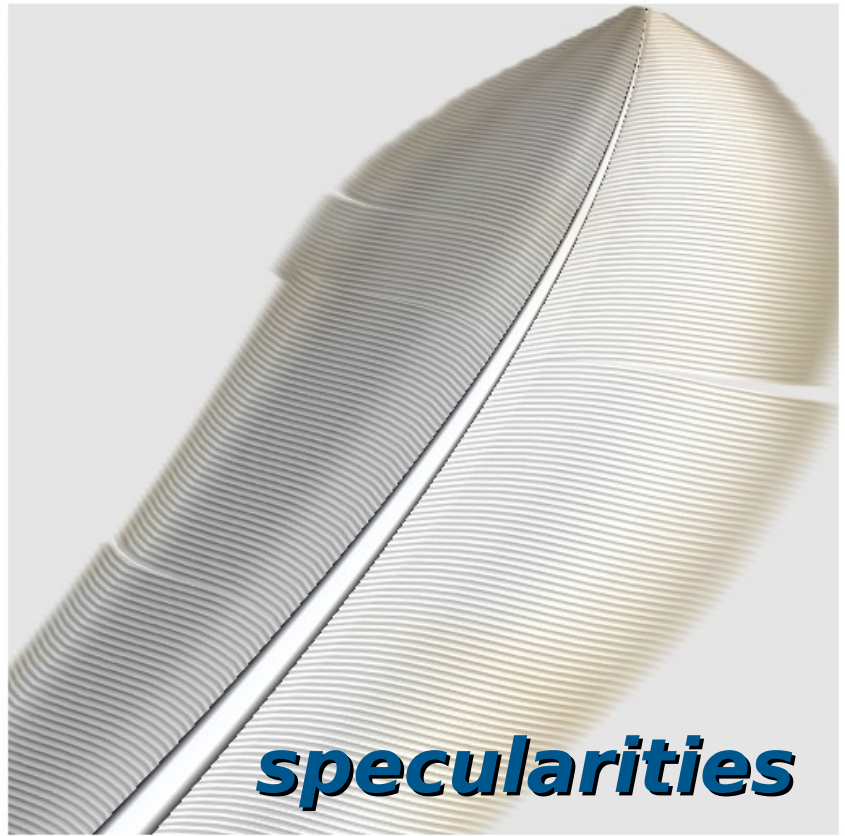
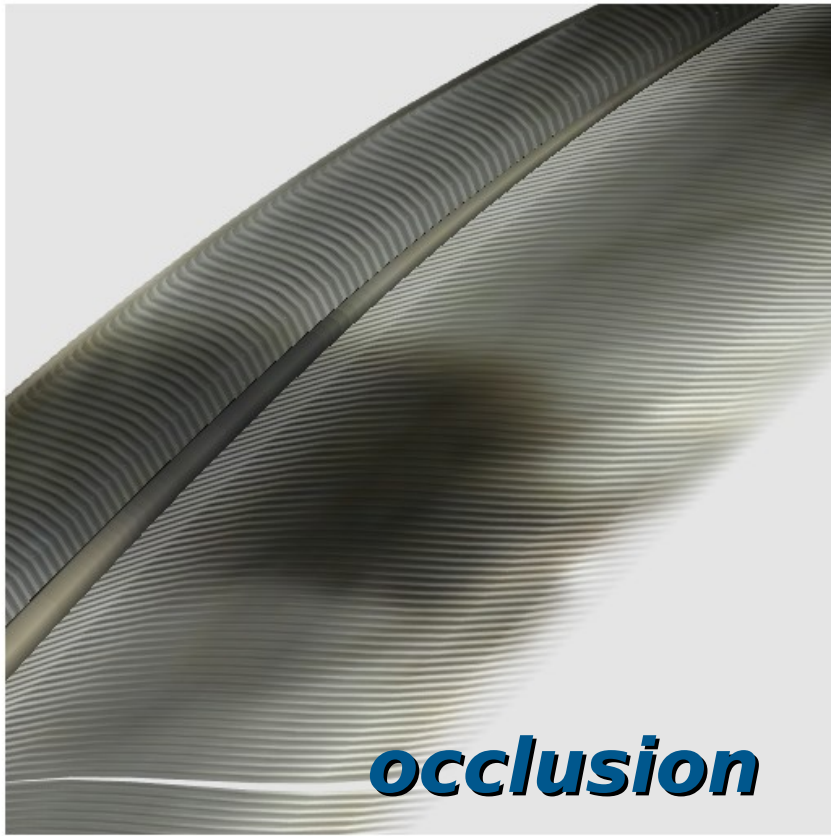
BTF vs Texture



Why BTF?

- **Realistic details in close-up views**
 - Mesostructures & directional radiance distribution
 - Occlusions & specularities
 - Oil film interference
- **LOD support for mipmap**

Occlusion & Specularities



Oil Film Interference

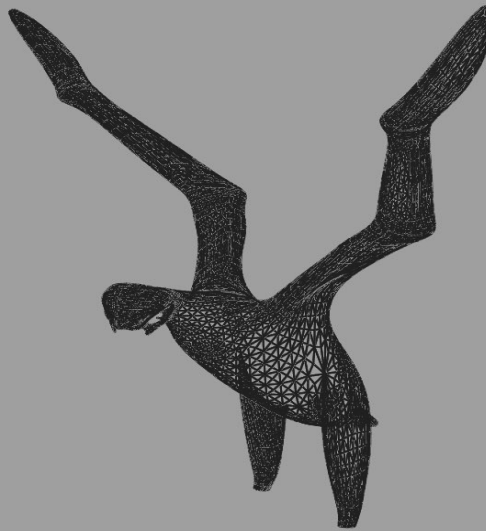
Gray feather with interference effect



Outline

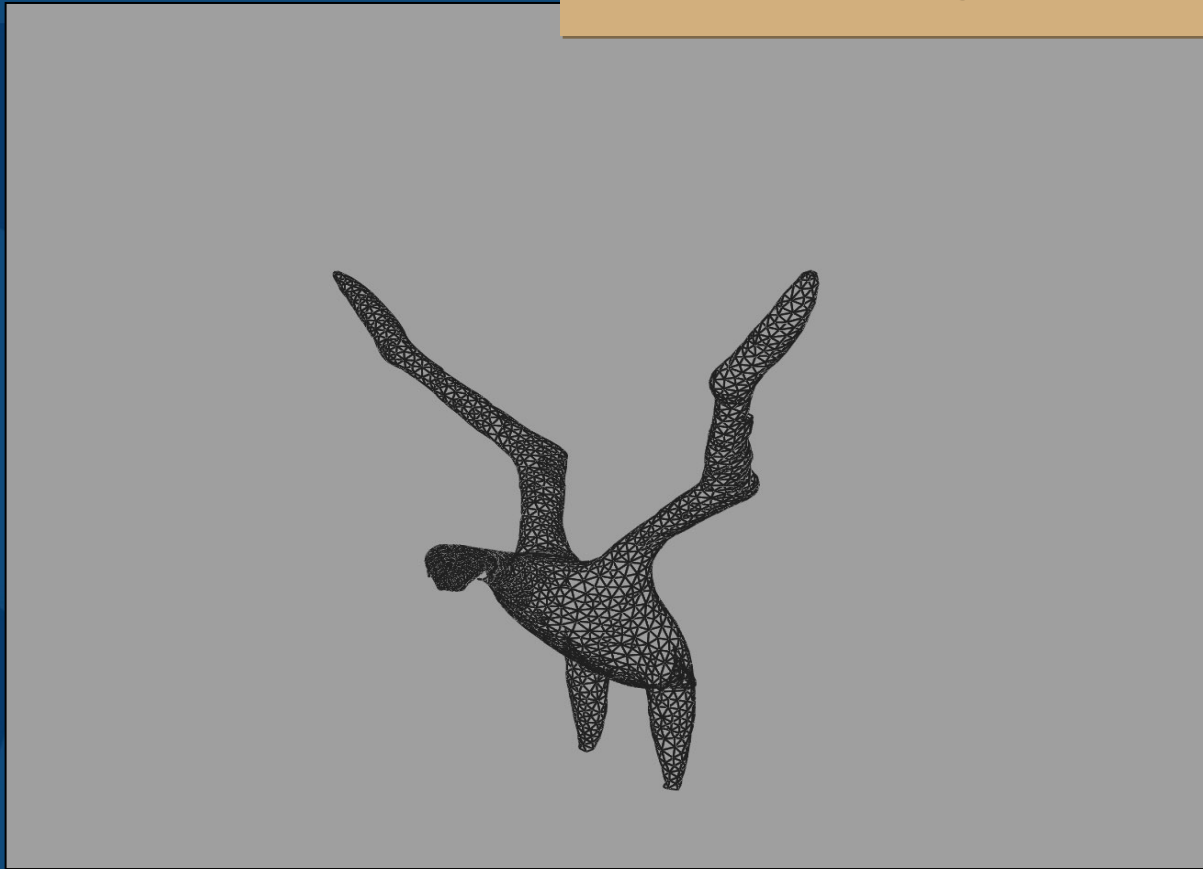
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Starting with a Bird Model



Finding Feature Positions

Biased retiling [Turk 91]



Specifying Key Feathers

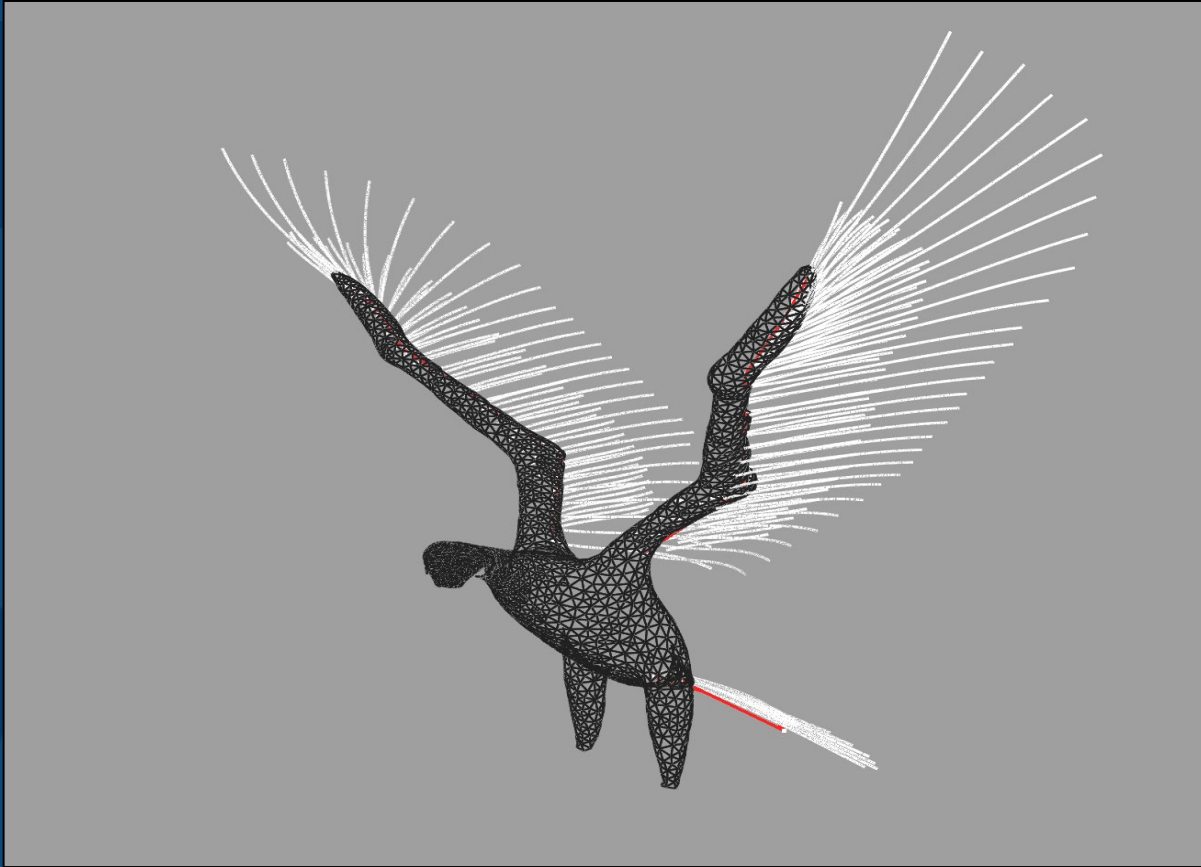


Initializing Feather Directions

RBF interpolation [Praun 00]



Adding Flight Feathers

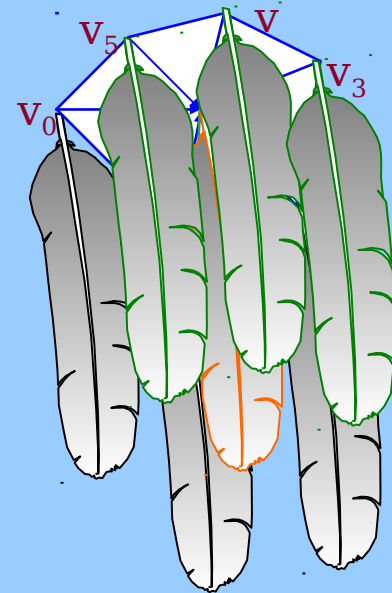


Recursive Collision Detection



Recursive Collision Detection

- **Only local collisions**
- **Collision detection in order**
 - For each vertex, sort surrounding vertices
 - Perform collision detection in order & adjust feather directions recursively
- **Use simplified geometry**



Recursive Collision Detection



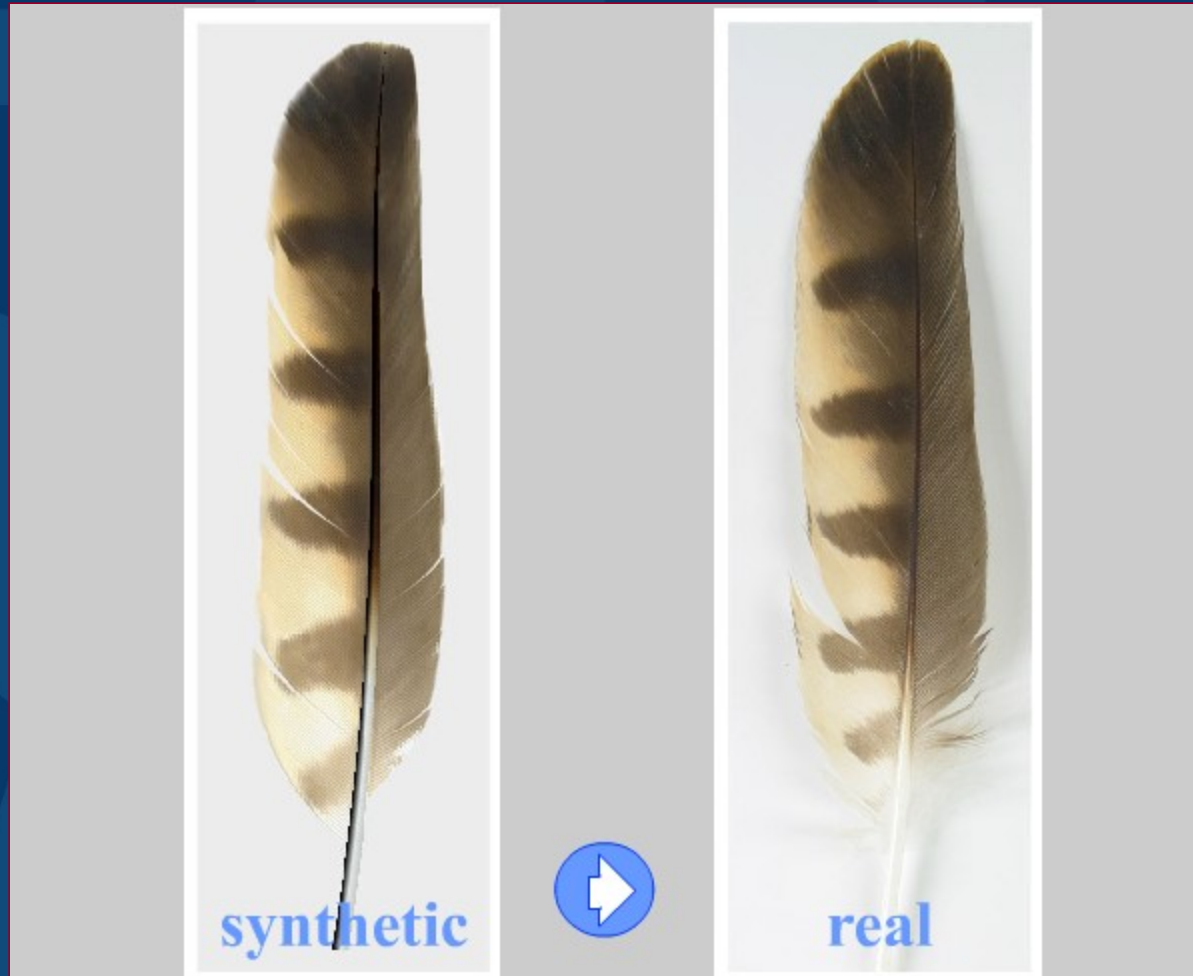
Recursive Collision Detection



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Real vs. Synthetic



Feathering a Bird



Summary

- **A comprehensive system for feather modeling & rendering**
 - L-system for feather geometry
 - BTF for feather appearance
 - Recursive collision detection for feather arrangement

Future Topics

- **Fine control of barbs**
- **Feather iridescence**
- **Bird animation**
- **& more!**